Economic Policy for the Information Economy—A Summary of the Bank's 2001 Economic Symposium

By Craig S. Hakkio

The economies of the industrialized countries are being reshaped by the rapid development and diffusion of advanced information and communications technologies. Access to information is unprecedented, and the ability to process and exchange information has helped businesses increase efficiency and households raise their standards of living. There has been considerable agreement as to the broad features of the emerging information economy. But there has been less consensus on the likely magnitude and significance of the economic effects or on the important policy issues raised by these developments.

The Federal Reserve Bank of Kansas City sponsored a symposium, "Economic Policy for the Information Economy," at Jackson Hole, Wyoming, on August 30–September 1, 2001. The symposium brought together a distinguished group of central bankers, academics, and financial market experts to examine how the information economy will alter the structure of economic activity. The symposium also served as a forum for addressing key policy challenges resulting from the information age changing the microeconomic and macroeconomic structure of the U.S. and foreign economies. Participants agreed that the information economy has changed the microeconomic and macroeconomic structure of the U.S. and foreign economies. The general consensus at the symposium was that long-run growth was probably 3 to 3½ percent, compared with 2¼ to 2½ percent in the 1980s and early 1990s.

Craig S. Hakkio is senior vice president and director of research at the Federal Reserve Bank of Kansas City. This paper is on the bank's website at www.kc.frb.org.

I. THE DIMENSIONS OF THE INFORMATION ECONOMY, MARKET STRUCTURE, AND FINANCIAL MARKETS

The first day of the symposium covered a variety of topics from various perspectives, including those of Federal Reserve Chairman Alan Greenspan, several current and former policy officials, a financial market participant, and several academic economists. The session began with a discussion of the dimensions of the information economy. Afterward, the session turned to a discussion of the microeconomic and financial market effects of the information economy. The day concluded with an overview of the international digital divide.

The wealth effect and national saving

In his opening remarks, Chairman Greenspan discussed some issues related to the wealth effect and the measurement of personal saving. Greenspan argued that the net wealth-income ratio is not sufficient for measuring the effect of capital gains on economic activity. He said that the effect depends on whether the capital gains are realized or not. Realized capital gains are made liquid with the potential to affect spending, assets, or debt. Unrealized capital gains can also affect spending, assets, or debt. But, unlike realized gains, unrealized capital gains remain on the asset side of the household's balance sheet, exposed to price change and uncertainty.

Greenspan also said that the effect of capital gains on spending depends on asset type. Regression analysis suggests that a $1 increase in overall household wealth leads to an increase of 3 to 5 cents in consumer spending. In addition, survey evidence suggests that a $1 increase in realized capital gains on the sale of homes (financed through the mortgage market) leads to an increase of 10 to 15 cents in consumer spending. Therefore, if both estimates are true, then the propensity to spend out of each dollar of stock market gain must be less than 3 to 5 cents on the dollar.[1] When housing price gains and stock market gains are similar in size, this difference in marginal propensity to spend may be insignificant. However, over the last year, stock prices have fallen while

home prices have risen. Thus, the overall effect may be positive or negative—depending on the total increase in stock market wealth and household wealth.

Greenspan went on to discuss the effect of capital gains on the measurement of personal saving. Since the national income and product accounts (NIPA) measure the market value of *output* of goods and services and its distribution to the factors of production, they exclude capital gains and losses. However, for many issues related to consumer spending, the NIPA personal saving rate "presents an incomplete picture of the financial state of the household sector in the aggregate."

Greenspan concluded by saying that separate sets of accounts should be developed to track capital gains. He said, "These accounts could supplement the income and product accounts, the flow of funds accounts, and the balance of payments accounts.…A supplementary set of detailed tables on capital gains exclusions from the national income and product accounts also would be a useful addition to our overall system of economic accounts."

The dimensions of the information economy

In their opening paper, "The 'New Economy': Background, Historical Perspectives, Questions, and Speculation," Bradford DeLong and Lawrence Summers argued that the IT revolution will have significant long-run effects on the economy and that the principal effects are more likely to be "microeconomic" than "macroeconomic." As a result, the new information economy will require changes in the way the government "provides property rights, institutional frameworks, and 'rules of the game' that underpin the market economy."

DeLong and Summers gave two reasons for the large impact of IT. First, the pace of technological progress in the IT sector is very rapid and will continue to be very rapid for the foreseeable future. For example, at the end of the 1950s, there were 2,000 computers processing 10,000 instructions per second. Today, 300 million computers are processing several hundred million instructions per second. In addition, instructions per second rose from 20 million to 90 quadrillion—a 4 billionfold increase in forty years. This translates into an annual growth rate of 56 percent per year. As the IT sector of the economy becomes a

larger share of the total economy, the overall rate of productivity growth will increase toward the rate of productivity growth in the IT sector. Second, the computers, switches, cables, and programs that are the products of today's leading sectors are general-purpose technologies. As a result, advances in high-technology affect all aspects of the economy, thereby leading to larger overall effects. While some argue that the crash of the Nasdaq suggests that the information economy was a mirage, DeLong and Summers disagree. They believe that the Nasdaq crashed because:

> It became clear to previously overoptimistic investors that the supply of bigger fools ready to buy overvalued stocks had dried up, and that dominant market positions in high-tech-based businesses were not sources of profits unless they came accompanied by substantial barriers to entry—and that such barriers to entry were turning out to be remarkably hard to create. Over a wide range, the dominant effect of the 'new economy' has been to make competition more effective, not to create scale-related cost advantages.

DeLong and Summers also argued that the microeconomic effects—how markets work—will have long-lasting and far-reaching effects on the economy. As a result, the role of the government in the economy needs to be re-examined. Since the creation of knowledge is cumulative, the importance of intellectual property rights becomes more critical in the new information economy. Three issues are interrelated: property rights over ideas, incentives to fund research and development, and the exchange of information among researchers. The authors also pointed out that analysts have generally believed that price discrimination was a way for monopolies to increase their profits. However, in the new information economy, price discrimination may be essential for attaining economic efficiency and maximizing social welfare.[2]

Finally, the authors argued that the new information economy is "Schumpeterian" rather than "Smithian." In a Schumpeterian economy, the production of goods exhibits increasing returns to scale. Under these conditions, the competitive equilibrium is not the likely outcome—setting price equal to marginal cost does not allow the firm to recover the large fixed costs. However, government regulation or government subsidies to cover fixed costs destroy the entrepreneurial spirit and replace it with "group-think and red-tape defects of administrative bureaucracy." In addition, when innovation becomes the principal source of wealth, temporary monopoly power and profits may be essential to spur innovation.

In discussing the DeLong and Summers paper, Alice Rivlin agreed that the IT revolution will have a lasting impact on our economy, but she was perhaps more skeptical than DeLong and Summers. Rivlin pointed out that most of the economy does not produce IT goods; a large part of the economy still produces and distributes food, clothing, shelter, home furnishings, cars, haircuts, and medical care.

Rivlin also reported on some of the insights provided from a recent Brookings study on the economic impact of the Internet.[3] A group of scholars estimated that the increased use of the Internet could add 0.25 to 0.5 percent to productivity growth over the next five years. Most of the impacts come from reducing the cost of data-intensive transactions (ordering, invoicing, accounting, and recruiting), from improved management of supply chains, from increased competition, and from increased efficiency of the wholesale and retail trade. In addition, many of the benefits of IT may result in improved standards of living, even though measured GDP is unaffected. Examples include reduced error rates in medical care delivery; a reduction in accidents, crime, and fraud prevention; and additional conveniences for consumers in the use of time and space.

Market structure in the information economy

Following up on DeLong and Summers' contention that most of the impact of IT will be microeconomic rather than macroeconomic, Hal Varian discussed many changes in the structure of the U.S. economy that emanate from advances in high-tech. His article, "High-Technology Industries and Market Structure," discussed nine effects of IT on the economy: the differentiation of products and prices, search, bundling, switching cost and lock-in, supply-side economies of scale, demand-side economies of scale, standards, system effects, and computer mediated transactions. Of these nine effects, two—supply-side and demand-side economies of scale—seem particularly important.

On the supply side, many information and technology firms have cost structures characterized by constant fixed cost and zero (near-zero) marginal costs. For example, a chip factory may cost billions of dollars

to build (high fixed cost); the cost of producing an additional chip is only a few dollars (near-zero marginal cost). Such industries are called "natural monopolies."

While natural monopolies often raise troubling policy issues, Varian offered several caveats. First, competition is often much more dynamic than generally thought. Since large scale provides a cost advantage, firms will compete to be the largest, benefiting consumers. Varian cited the example of Amazon.com, which built market share by offering consumers low prices. Second, if the overall market is growing fast enough, it is easier for firms to overcome the scale advantage of existing (large) firms. Here, Varian cites the example of WordStar and WordPerfect being eclipsed in the word-processing market and VisiCalc and Lotus in the spreadsheet market. As Varian put it: "Market share alone is no guarantee of success." Third, IT has often reduced the minimum scale of operation. For example, one person with a $1,000 PC can now produce a reasonably professional layout. Against these benefits, though, it is still generally true that in such markets price will exceed marginal cost, leading to conventional forms of inefficiency.

Another characteristic of many information goods is that they exhibit "network externalities" or "demand-side economies of scale." A product exhibits network externalities if one person's demand depends on how many others use the product. The fax machine is the classic example of a "direct network effect." A DVD exhibits an "indirect network effect" because the demand for DVDs depends on how many DVD movies are available, which, in turn, depends on how many people own DVDs. Such indirect network effects are common in information goods when hardware depends on the availability of software and the availability of software depends on hardware. This is the basis for the argument that the cure for the current IT slump is a "new killer ap."

When information goods exhibit both supply-side economies and network effects, the interaction is particularly powerful. In such a case, more sales lead to lower costs (supply-side economies of scale) and greater demand by consumers (network effects). While not inevitable, once a firm achieves significant market share, it will be difficult to overtake the firm.

In discussing the Varian paper, Erik Brynjolfsson focused his remarks on the implications of the information economy for bundling and for search. Brynjolfsson used the book retailing market to discuss how IT can lead to greater concentration and greater competition. For example, there are more than 30,000 physical bookstores and very few booksellers on the Internet.[4] With the greater concentration in online booksellers, one might expect higher prices. In fact, prices are 10 to 12 percent lower. The paradox is resolved by observing that it is much easier to search and find competitors on the Internet. A book buyer may be geographically near only one bookstore, but has access to all online booksellers. Brynjolfsson put it this way: "Geography and ignorance provide very powerful barriers and allow that bookstore to have higher prices. On the Internet, competition is only a mouse click away. As a consequence, that prevents even a relatively concentrated industry from raising prices nearly as much."

The size of the search cost savings can be significant. In a research study involving students making Internet purchases, Brynjolfsson found that the Internet was at least 30 times cheaper than using the telephone and about 300 times cheaper than physically visiting the store. Moreover, evidence from General Motors suggests that a typical purchase order costs $118 when handled through conventional channels but only $8 when handled over the Internet. And, evidence from Fleet Bank suggests that a business transaction inquiry handled over the telephone costs $1.25, while over the Internet it costs 2 to 3 cents.

Kevin Murphy also commented on Varian's paper. While recognizing that the effect of technology on consumer welfare is ambiguous, Murphy was "much more optimistic." He argued that competition can take many different forms and that market concentration may not be a useful measure of consumer welfare. For example, even though ex post competition is light (when there are high fixed costs and zero marginal costs), ex ante competition will be more vigorous. Moreover, competition is much more complex than most economic models might suggest. Firms may compete on the choice of standards or the choice of contracts.

In addition, while information markets may be more concentrated, market structure is not an end in itself. Rather, economists care about market outcomes in terms of price, output, and technological improvement—things that affect consumer welfare. Murphy elaborated on this

theme by showing the ways in which "many of the forces that lead to greater concentration do so precisely because they enhance competition and/or make outcomes with greater concentration more efficient." For example, in the presence of network effects, concentrated markets exploit the gains from a large network—leading to lower prices that benefit consumers. Murphy emphasizes a trade-off in which the outcome can be a single firm (maximizing the network benefits) or a few firms (giving up some network benefits for greater ex-post competition).

Finally, in looking at actual technology markets, Murphy found: "These markets are incredibly competitive. Even markets with high concentration, such as the PC operating system market, are characterized by remarkably low prices and rapid rates of technical progress and market growth."

The financial market effects of the information economy

In their paper, "Technology, Information Production, and Market Efficiency," Gene D'Avolio, Efi Gildor, and Andrei Shleifer discussed the effect of technology on securities markets. They argued that a well-functioning securities market depends on four key factors: accurate information, investors with access to the information, legal protection of investors' rights, and a liquid secondary market. They argued that advances in technology have improved the functioning of the securities market in the last three factors, but that the quality of information has deteriorated.

The Internet has led to a significant increase in the quantity of information available to investors. With greater information, the number of participants in financial markets has increased dramatically. For example, the number of Americans participating in the equity market has increased from 52 million in 1989 to 84 million in 1998. Technology has also driven down trading costs. The authors cite a study that one-way transaction costs (half-spread + NYSE commission) over the last 20 years fell from 1.0 percent to 0.2 percent. Moreover, "decimalization reduced effective spreads on the NYSE to roughly $0.06 for high-volume stocks."

While increasing the quantity of information and reducing the cost of trading, technology has also reduced the quality of information. The effect of technology on the quality of information has two elements. First, as technology drives down trading costs and more investors begin trading, the marginal investor is "less experienced, less sophisticated, and less able to derive fundamental security values from raw information." As an example, the authors presented evidence that Nasdaq stocks are more likely to be held by individual, retail investors, than by institutional investors. Thus, they concluded that it "appears to be predominantly individuals…who are determining prices in the technology heavy Nasdaq market, which has benefited most from unrealistic stock valuations."

Second, the authors argued that changes in the economy "create strong incentives for firms to distort the information they produce to the investor community." Since the authors do not believe that financial intermediaries can privately solve the problem of information quality, they advocated investor education programs and the regulation of information disclosure.

In commenting on the paper by D'Avolio, Gildor, and Shleifer, Roger Ferguson agreed with the policy implications advocated by the authors. However, Ferguson disagreed with the authors' conclusion that information technology has "brought unsophisticated investors in droves to the stock market." He cited several pieces of evidence. If the assertion were true, he said, one would expect to see direct holdings of equities by households become a larger share of total equities outstanding. In fact, survey evidence suggests that while the number of households owning equities has increased, the share held directly has remained roughly constant during the last decade. In addition, the characteristics of households that first bought individual stocks after 1995 is similar to the households that first bought individual stocks between 1990 and 1995.

Ferguson also elaborated on the impact of technology on the retail financial market. He pointed out that technology has increased the number of providers of credit cards, mortgages, and small business loans. In addition, technology has allowed loan originators to separate risk from return and to sell the risk to the parties most willing to bear it through securitization. Technology has also enhanced the ability of lenders to evaluate and price credit risk. As Ferguson summarized, "In

short, while the paper raises important concerns about equity markets, other areas of finance provide evidence that the information age has brought significant benefits in the form of increased transparency and competition, lower costs, more appropriate pricing, and broader access to credit."

In his comments, Philipp Hildebrand raised the question of whether the concern about the quality of information reflects the impact of technology or "deeper structural or perhaps even cultural forces at work that have amplified the consequences of the information revolution." In particular, some of the excesses might reflect a new capitalist spirit and American culture. As one bit of evidence, Hildebrand argued that the impact of the information revolution in Europe was very different than in the United States.

Hildebrand agreed with the authors' conclusion about the need for regulatory initiatives. However, he also urged caution: "As a practitioner, I find myself rather in favor of the argument that financial markets are not always efficient. I do worry a great deal, however, that misdirected regulatory attempts may render markets even more inefficient.…The role for government in the information economy is bound to be a limited but an important one."

Reducing the international digital divide

In the luncheon address, "Reducing the International Digital Divide," Donald Johnston argued that a digital divide can arise from a number of sources. He used the automobile as an analogy: "So we need highways, access to highways, vehicles, trained drivers, and instructors. And we also need the rules of the road consistently applied.…The absence of any one of these elements creates a digital divide." Johnston pointed out that more than 60 percent of people in Norway use the Internet, while less than 5 percent use the Internet in Indonesia and Ukraine. (In the United States, between 55 and 60 percent use the Internet.)

Johnston felt that the recommendations of a 1969 United Nations Commission on International Development remain valid today—namely, "a major effort is needed to revitalize education and increase the

capacity to absorb, adapt, and develop scientific and technical knowledge in developing countries." Information and communication technology (ICT) is an important tool in helping to achieve this objective.

Access is a key challenge. More than 95 percent of Internet hosts and secure servers used for electronic commerce reside in OECD countries. While the public sector will play a role, Johnston believes that the private sector will play a key role. Getting private sector involvement will depend on "good governance." Johnston stated that "applications of the rule of law, market liberalization, fair competition laws, an appropriate regulatory framework, a well functioning financial sector, and so on, are all part of that good governance infrastructure." Johnston provided two examples. Following the opening of the telecommunications market to competition, the number of fixed and wireless telephone lines in Uganda quadrupled in two years (from 40,000 to nearly 160,000). In Sri Lanka, the number of telephone lines per 100 inhabitants went from one to six in four years.

Johnston concluded with this recommendation: "As for developing countries, educate people, build good clean governance, apply the rule of law, liberalize telecommunications markets: Create that environment, and private investment will come. The digital divide will start to close."

II. MACROECONOMIC AND MONETARY POLICY IMPLICATIONS OF THE INFORMATION ECONOMY

The second day of the symposium focused on macroeconomics and monetary policy. It started with a discussion of the broad macro implications of the information economy. It then turned to two important monetary policy issues arising from the information economy. The day concluded with an overview panel that addressed what the future might hold.

Macroeconomic implications of the new economy

Martin Neil Baily, in his paper titled "Macroeconomic Implications of the New Economy," surveyed some of the macroeconomic implications of the information economy. Since 1995, real growth has increased. From 1973 to 1990, real GDP growth averaged 2.9 percent;

since 1995, it has averaged 4.1 percent. Productivity growth has shown similar increases, averaging 1.9 percent from 1973 to 1990, and 3.2 percent since 1995. The conclusion is clear. "The strong growth of the U.S. economy after 1995 is linked to a recovery of productivity growth." To be sure, though, the recovery lasted only five years.

The emergence of the information economy has been a key feature of faster productivity growth. Information technology has affected productivity in two ways. First, the IT sector itself has contributed directly to stronger productivity. Computers and other IT hardware have become better and cheaper, leading to increases in investment, employment, and output of the IT sector. Second, advances in technology have also increased productivity in the more traditional sectors of the economy—financial services, business services, and the retail and distribution industries.

According to Baily, U.S. economic policy has also contributed to a revival in productivity growth. "Policies to maintain domestic competition and increase international competition have been stressed. Funds have been provided to support basic research and education. And, most importantly, the mix of monetary and fiscal policy has lowered interest rates and encouraged investment."

In commenting on Baily's paper, Takatoshi Ito focused on the implications of the new economy for Japan (a topic covered only briefly by Baily). Ito observed that if the new economy is a permanent feature of the global economy, it should be felt in Europe and Japan. It has not. Interestingly, though, both Europe and Japan experienced the same IT stock price bubble observed in the United States. For example, the Nikkei rose from 13,000 in the fall of 1998 to 20,000 in February-March, 2000, and then crashed to 11,000 at the end of August 2001 (the time of the symposium). Ito asked, "If so, why was the stock market bubble internationally common while the real economy IT revolution was not?"

In explaining why Europe and Japan did not share in the U.S. productivity revolution, Ito partly agreed with Baily but added a slightly different slant. He argued that Japan (as well as Europe) has been less successful in applying IT advances to other industries (rather than in producing IT products). He added that organizational structure and incentives are more important than regulatory barriers. He blamed

labor practices and capital markets. In particular, Japanese society and schools produce highly educated and well-trained workers, but not innovative workers. Taking risk is not highly rewarded in Japanese companies. Since the application of IT to other industries is risky, Japan has been less successful.

In discussing Baily's paper, John Taylor argued that "greater openness and freedom of entry will lead to greater productivity growth in regions where it has been lacking." Baily reported evidence on the difference between the price of a particular good in a country and the lowest price of that same good in the world. This difference is a measure of competitive forces. On average, prices in the United States are 15 percent higher than the lowest prices in the world, while UK prices are 42 percent higher, German prices are 60 percent higher, and Japanese prices are 85 percent higher. The policy implication is that trade liberalization, which leads to greater competition, can lead to faster productivity growth.

Taylor suggested that IT might have led to less cyclical volatility by improving monetary policy. The cyclical volatility of the U.S. economy fell in the early to mid-1980s. In the past, Taylor has argued that an improvement in overall macroeconomic policy, and monetary policy in particular, contributed to this decline. Taylor said, "Although it is speculative, I believe improved…analysis (including seasonal adjustment), better econometric models, and more timely analysis of data have all helped improve macro policy formulation and implementation."

Monetary policy in the information economy

While many analysts have suggested that the information economy might reduce the ability of central banks to influence financial markets, Michael Woodford argued this is not the case. In his paper, "Monetary Policy in the Information Economy," he argued that even in a world with frictionless financial markets and a well-informed public, central banks will be able to conduct monetary policy—perhaps even more effectively—to guarantee price stability. However, the specific operating procedures will need to change.

The information economy can improve the effectiveness of monetary policy by allowing the private sector to better anticipate future central bank actions. Central banks typically operate by affecting overnight

interest rates (such as the federal funds rate in the United States). By affecting current overnight rates and, most important, by affecting market expectations of future rates, monetary policy can affect financial market prices such as long-term interest rates, exchange rates, and equity prices. These prices, Woodford argued, have the greatest effect on economic activity.

Since the ability of a central bank to influence economic activity depends critically on its ability to affect market expectations about the future path of overnight interest rates, clarity about actions and intentions can enhance the effectiveness of central banks. If a central bank's intentions are clear, Woodford suggested, the actual change in the overnight interest rate can be more modest than otherwise (because expected future short-term rates will change as well).

Woodford drew several lessons for the conduct of monetary policy. First, monetary policy should be transparent and central banks should explain their decisions to the public. Second, central banks should lead the markets. Being transparent and not surprising financial markets do not mean that central banks should always act to meet market expectations. If a central bank always delivers what markets expect, then there is no objective anchor for financial market expectations. Changes in expectations would become self-fulfilling because the central bank validates them. This, in turn, would be destabilizing. Third, policy should be rule-based. If a central bank does not follow a rule, then the public will never be able to understand and anticipate central bank actions.

Woodford also addressed a controversy in monetary theory. Several authors have argued that the information economy will reduce, or perhaps eliminate, the demand for central bank money. If there were no demand for central bank money, the central bank would be unable to affect the overnight interest rate, thereby preventing the central bank from influencing economic activity and maintaining price stability. Woodford argued that this concern is misplaced.

Monetary policy affects economic activity and prices through its control of overnight interest rates. Overnight rates are determined in the interbank market for central bank balances held by banks to meet reserve requirements and to clear payments. Improvements in information tech-

nology may reduce the demand for central bank balances to meet reserve requirements. But, even if reserve requirements were eliminated, a demand for central bank balances would remain for clearing purposes.

As long as there is a demand for clearing balances, Woodford argued, central banks could control the overnight interest rate by controlling the net supply of central bank balances. However, targeting the quantity of central bank balances is unlikely to be effective because the demand for clearing balances is small relative to the total volume of payments in the economy. Woodford pointed out that U.S. banks that participate in the payments system send and receive payments each day that are about 30 times the size of their average daily overnight clearing balances, and the ratio is closer to 200 for the most active banks.

Woodford believes that while quantity targeting is not practical, central banks can—and some already do—control the overnight interest rate through using a "channel" system. The channel system keeps the overnight rate between two rates, a lending rate and a deposit rate, which are determined by the central bank's introduction of two standing facilities. The central bank stands ready to lend any amount of overnight balances at a fixed lending rate, which is set above the desired overnight interest rate. The central bank also stands ready to let banks deposit excess clearing balances overnight and earn a deposit rate, set below the desired overnight interest rate. The lending rate is above, and the deposit rate is below, the desired overnight interest rate so that banks have an incentive to use the interbank market.

In a channel system, the demand for clearing balances is a function of the desired overnight rate *relative* to the lending rate and deposit rate. It is independent of the *level* of any of these interest rates. As a result, changes in the desired overnight rate can occur without any change in the supply of clearing balances.

In discussing Woodford's paper, Robert Hall agreed "strongly with everything" in Woodford conclusions. Hall first provided a different perspective on a purported need for secrecy in monetary policy, stemming from a misunderstanding of the work by Robert Lucas. Hall pointed out that Lucas had argued that perceived changes in the money supply were immediately reflected in changes in the price level. There-

fore, "if a monetary policy works when it is easily capable of controlling the price level, then the concern is backward—in the Lucas model, price level control is improved by disclosure of monetary policy."

Hall also agreed with Woodford's point that a central bank can peg a short-term interest rate, regardless of its portfolio size. Hall provided a simple example. During the gold standard, changes in the interest rate could be accomplished via changes in the gold content of the dollar. The key point is that the central bank issues the security that defines the dollar. By adjusting the quantity of, or interest paid on, the security, the central bank can control the price level.

In commenting on Woodford's paper, Mervyn King, elaborated on the importance of transparency and communication. In particular, he discussed what the central bank should communicate. In King's view, the central bank should communicate the timeless aspect of its decisions, not the ad hoc justification for a particular decision. Of course, in an ever-changing and complex economy, there is no timeless model for the economy and, therefore, no timeless "policy reaction function." In such a world, what should central bankers communicate?

If the economy, and our understanding of the economy, is always changing, King suggested, then a central bank should communicate how it is learning about the economy and what lessons it has drawn from recent experience. As the nature of the economy changes, monetary policy committees become more important for making monetary policy decisions than simple (or even complex) econometric models. King argued that central bank communication must guide the public along an intellectual journey, indicating what it does and does not understand, rather than hinting at what it may or may not do at the next meeting.

Overview panel

The symposium concluded with overview comments and perspectives on the future from Martin Feldstein, Christian Noyer, and Janet Yellen.

Feldstein believes that recent advances in information technology will lead to continued strong productivity growth, and, therefore, overall economic growth. In addition, based on research by the National Bureau of Economic Research, he believes that gains in productivity will

come from reducing the number of *nonproduction* workers per unit of output. Through visits to manufacturing firms, researchers from the NBER noted that most employees in manufacturing firms are not engaged in production, but rather in nonproduction activities, such as sales, accounting, and purchasing. Advances in IT can eliminate many of these middle management jobs and can help reorganize the production process. Feldstein observed that "an increase in productivity growth from the historic 1.5 percent a year to 2.5 percent represents an annual reduction of only one employee in 100—i.e., doing the work with 99 employees that would have been done with 100 the year before. There are many opportunities for such progress to continue in the future."

Feldstein also addressed an issue raised in various papers and discussed throughout the symposium: namely, why has productivity increased in the United States but not in Europe or Japan. Feldstein believes there are three reasons for this. First, rigid labor and product markets make it difficult for companies to reorganize production and support staff activities. If a company cannot take advantage of new technology by reorganizing production activities, then it will not adopt new technology. Second, product markets are less competitive in Europe and Japan than in the United States. Third, managers in Europe and Japan have less personal incentives to adopt new information technologies than managers in the United States. For example, bonuses and stock options are common ways to motivate managers in the United States but not in Europe or Japan.

According to Feldstein, there is one potential downside to the Internet revolution. He believes that the Internet has facilitated the anti-globalization movement, hindering the new global trade round.

In his overview remarks, Noyer focused on the implications of the information economy for Europe and the European Central Bank. While recognizing the impressive growth performance of the United States during the last five years, Noyer noted that labor productivity grew faster in Europe than in the United States during the previous two decades. However, he did recognize that Europe is lagging in its ability to exploit new technology in the IT-using sector.

Noyer was also relatively optimistic about Europe's economic prospects. Recognizing the importance of competition for encouraging the information economy, he said that the European single market for

goods and services has increased competition in Europe. In addition, he felt that the introduction of the euro has enhanced competition across Europe because cross-country price comparisons are more transparent. The European Central Bank has also helped create a stable macroeconomic environment, which is important for investment and the adoption of new technology. Monetary union has also facilitated financial market deepening, providing greater financing alternatives for entrepreneurial firms. Finally, monetary union has increased competition among governments to have the best possible and most flexible policies.

In her comments, Yellen highlighted the policy lessons of the symposium. First, economic policy matters to productivity growth. As she said, "A regulatory environment and institutions that facilitate the reallocation of labor and capital are likely to improve both static efficiency and also the dynamic gains from innovation." Second, the information economy may increase wage inequality by increasing the return to exercising judgment, solving problems, and working in teams. Third, stronger productivity growth makes an economy less susceptible to inflation by reducing the NAIRU—at least for a time.

Yellen also discussed how IT may affect the volatility of the macroeconomy. First, through facilitating the adoption of just-in-time inventory techniques, new technology has influenced inventory behavior. Second, IT could affect volatility through its impact on international trade. Finally, IT could lead to increased systemic risk in financial markets and potentially destabilize financial markets.

Information technology might also affect the channels through which monetary policy affects the economy. For example, she raised a question first discussed by Euro-currency Standing Committee of the G-10 in its 1994 Hannoun Report: Have the spending decisions of consumers and firms become immune to interest rate and exchange rate fluctuations due to the increased use of derivatives? If so, the transmission mechanism that operates through the credit availability channel might be diminished.

Finally, Yellen recognized the importance of technology for the increase in global capital mobility. As Robert Mundell explained in the 1960s, perfect capital markets make it impossible for central banks to simultaneously conduct independent monetary policy and peg the exchange rate. They need to choose one or the other. Yellen concluded by

predicting that "in the decades ahead, a growing number of central banks will decide to close shop, abandon an independent currency, and dollarize or join a currency area rather than live with the often destabilizing economic consequences of flexible exchange rates. This development, if it happens, can be viewed as a logical consequence of the IT revolution."

ENDNOTES

[1] Of course, in the last few years, the stock market gains have been larger in magnitude. As a result, the dollar magnitude would be larger for stock market gains than housing price gains.

[2] DeLong and Summers cited the pharmaceutical industry as a good example. They asked, "Does anyone doubt that good public policy today should focus on providing drug companies with powerful incentives and tools for them to charge radically different prices to consumers in rich and in poor countries?"

[3] "The Economic Payoff from the Internet Revolution," Robert E. Litan and Alice M. Rivlin, eds., Washington: Brookings Institution Press, 2001.

[4] According to Brynjolfsson, there are a few thousand online retailers, but three of them control about 85 percent of the market.